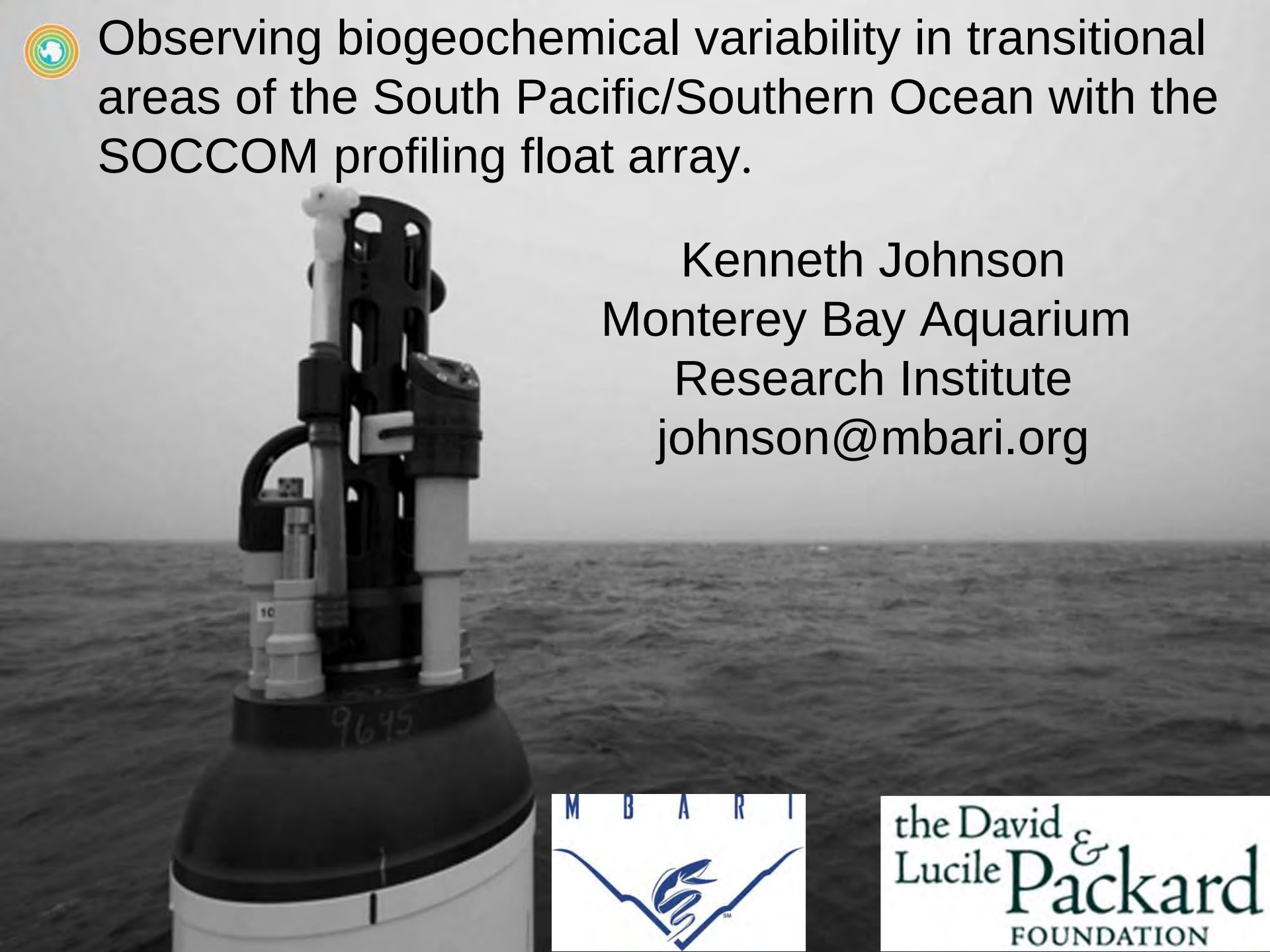
# Observing biogeochemical variability in transitional areas of the South Pacific/Southern Ocean with the SOCCOM profiling float array.



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M B A R I

the David & Lucile Packard FOUNDATION

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# Thanks to:

MBARI
Luke Coletti
Hans Jannasch
Carole Sakamoto
Josh Plant
Tanya Maurer
Gene Massion
Ginger Elrod
Peter Walz






SOCCOM

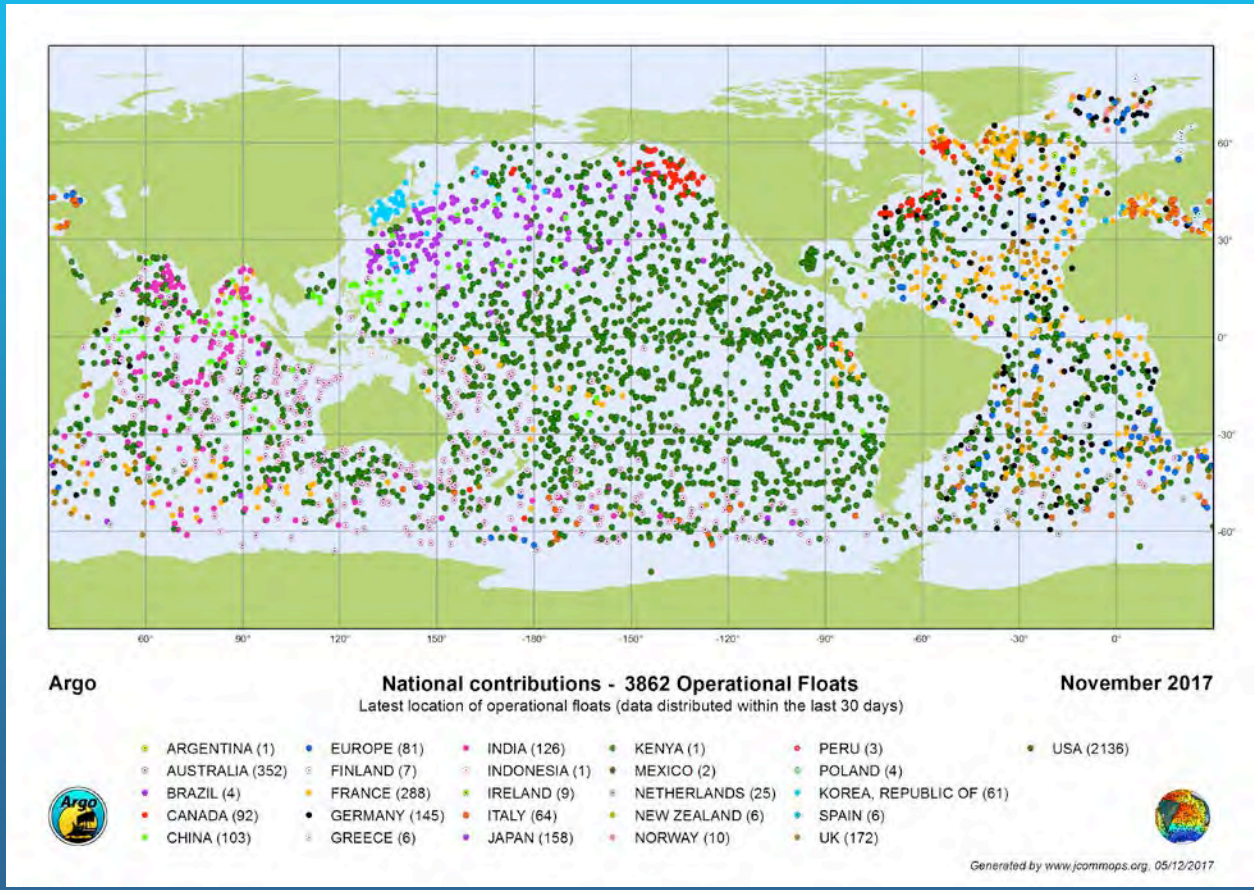
Outline:

- Biogeochemical Argo floats and sensors
- The SOCCOM (Southern Ocean Carbon & Climate Observations and Modeling) Project
- Transitional area observations and processes
- Prospects for a global system

# Argo autonomous profiling floats

Transformed heat and freshwater observing into global observing

- 3500 to 4000 floats
- Temperature and salinity profiles
- Every 10 days to 2000 m

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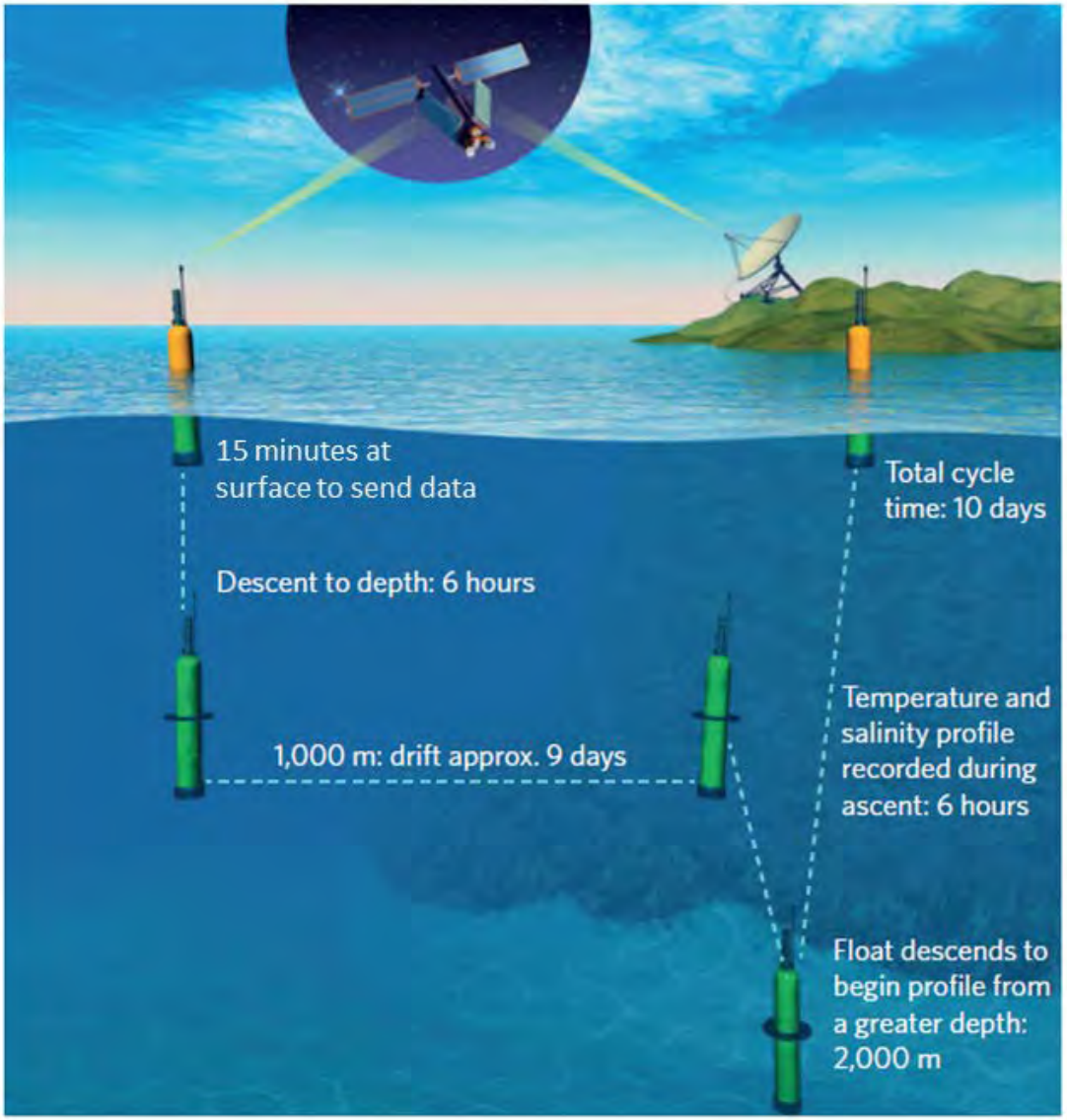


The Argo float cycle.

A BGC equipped float has enough energy for ~250 cycles at 10 day intervals.

2500 days = ~7 years

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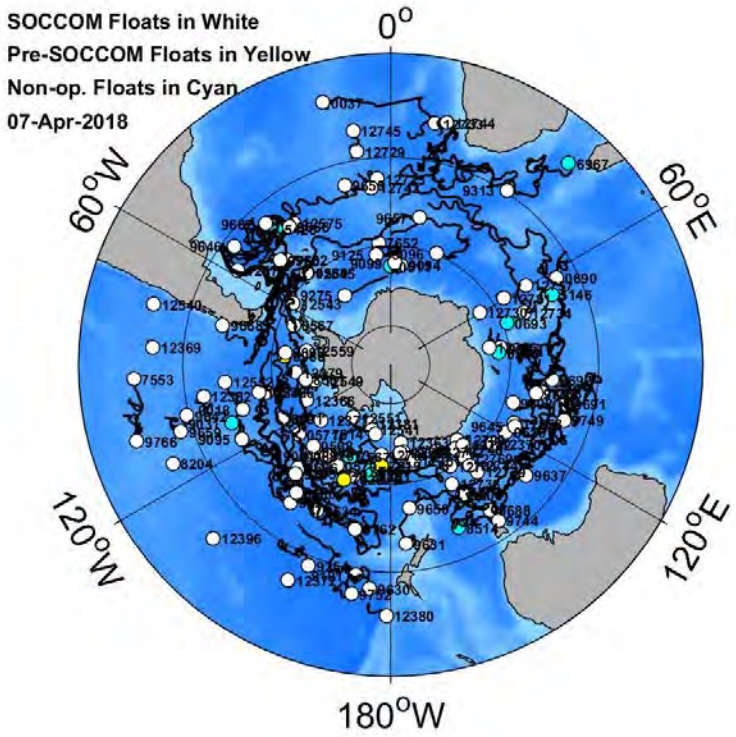
- 123 floats deployed with $O_2$, $NO_3^-$, pH, and bio-optical sensors
- 108 active floats
- 179 float years of data
- **All data publically available: soccom.princeton.edu & at Argo Global Data Assembly Centers**

How good are the chemical sensor data?

What do we learn about biogeochemical processes?

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# Oxygen measured on floats by fluorescence lifetime.

JOURNAL OF ATMOSPHERIC AND OCEANIC TECHNOLOGY
MARCH 2005

## High Quality Oxygen Measurements from Profiling Floats: A Promising New Technique

ARNE KÖRTZINGER AND JENS SCHIMANSKI

*Marine Biogeochemistry Department, Leibniz-Institut für Meereswissenschaften, Kiel, Germany*

UWE SEND


Aanderaa (AADI)
Optode 4330

Sea-Bird
Optode SBE 63

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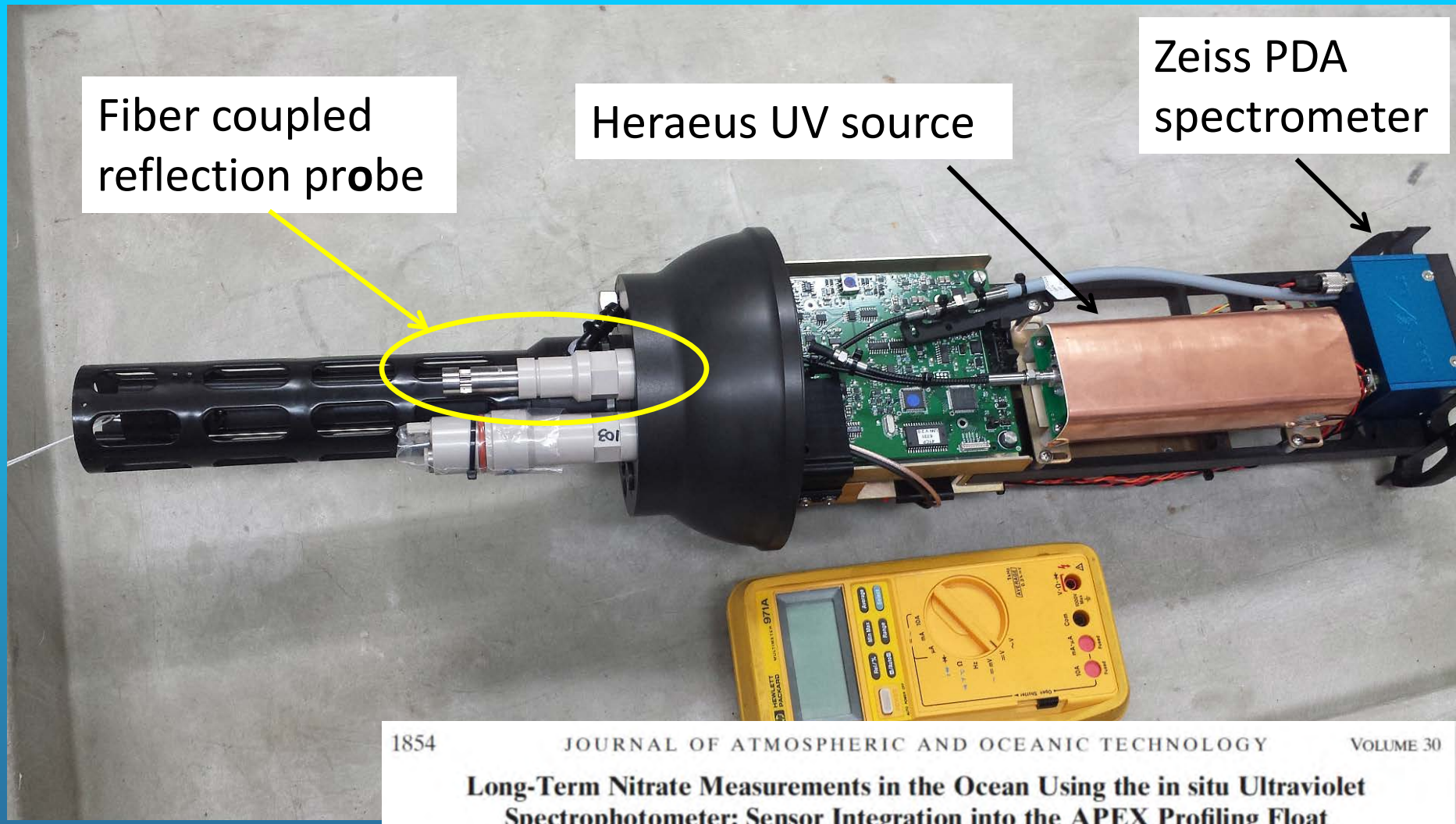
# UV optical nitrate sensors on floats (ISUS or SUNA)






**Long-Term Nitrate Measurements in the Ocean Using the in situ Ultraviolet Spectrophotometer: Sensor Integration into the APEX Profiling Float**

KENNETH S. JOHNSON, LUKE J. COLETTI, HANS W. JANNASCH, AND CAROLE M. SAKAMOTO

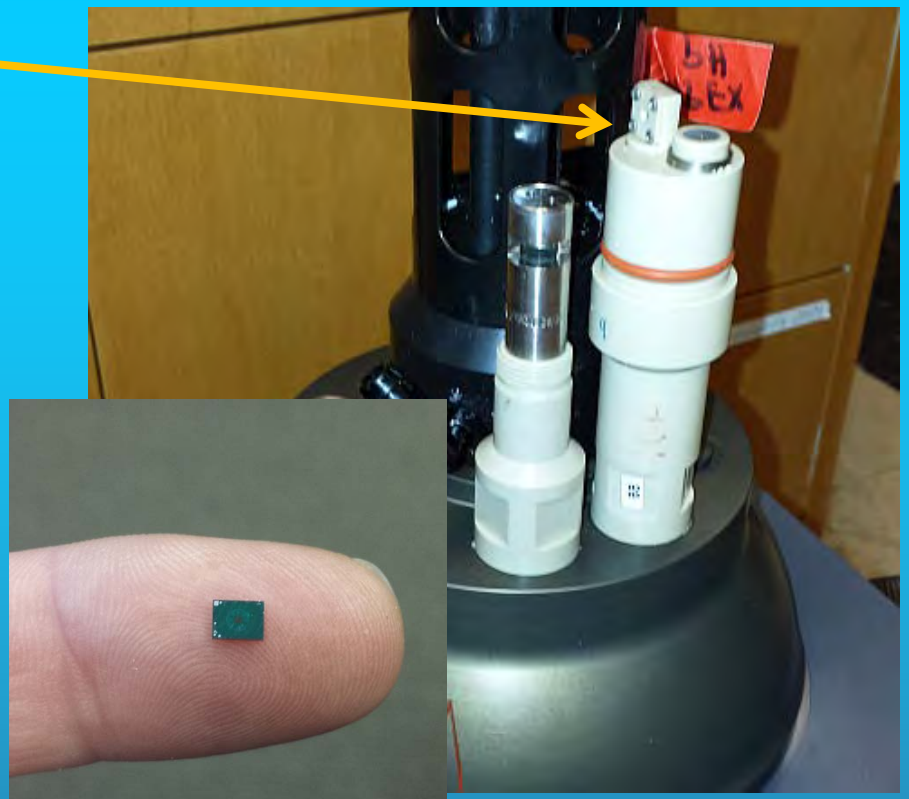
*Monterey Bay Aquarium Research Institute, Moss Landing, California*

DANA D. SWIFT AND STEPHEN C. RISER

*School of Oceanography, University of Washington, Seattle, Washington*

# Ion Sensitive Field Effect Transistor pH sensor.

- Solid-state transistor pH sensor developed by Honeywell
- Adapted for ocean sci. by MBARI
- Commercialized by Seabird.



analytical chemistry

Article

pubs.acs.org/ac

## Deep-Sea DuraFET: A Pressure Tolerant pH Sensor Designed for Global Sensor Networks

Kenneth S. Johnson,*,† Hans W. Jannasch,† Luke J. Coletti,† Virginia A. Elrod,† Todd R. Martz,‡ Yuichiro Takeshita,‡ Robert J. Carlson,§ and James G. Connery¶

Sea-Bird Scientific (WETLabs) FLBB chlorophyll fluorometer & optical backscatter (particles) sensor


*Limnol. Oceanogr.*, 53(5, part 2), 2008, 2112–2122


Observations of pigment and particle distributions in the western North Atlantic from an autonomous float and ocean color satellite

*E. Boss*[1]
School of Marine Sciences, University of Maine, Orono, Maine 04469

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These are remarkable sensors, but in situ calibration corrections are still essential.
Protocols well established.

LIMNOLOGY and OCEANOGRAPHY: METHODS

ASLO

*Limnol. Oceanogr.: Methods* 14, 2016, 491–505

doi: 10.1002/lom3.10107

## Accurate oxygen measurements on modified Argo floats using in situ air calibrations

Seth M. Bushinsky,[†]* Steven R. Emerson, Stephen C. Riser, Dana D. Swift
[1]School of Oceanography, University of Washington, Seattle, Washington

frontiers in Marine Science

ORIGINAL RESEARCH
published: 24 January 2018
doi: 10.3389/fmars.2017.00429

## Oxygen Optode Sensors: Principle, Characterization, Calibration, and Application in the Ocean

*Henry C. Bittig[1]*, Arne Körtzinger[2,3], Craig Neill[4], Eikbert van Ooijen[4], Joshua N. Plant[5], Johannes Hahn[2], Kenneth S. Johnson[5], Bo Yang[6] and Steven R. Emerson[6]*

Journal of Geophysical Research: Oceans

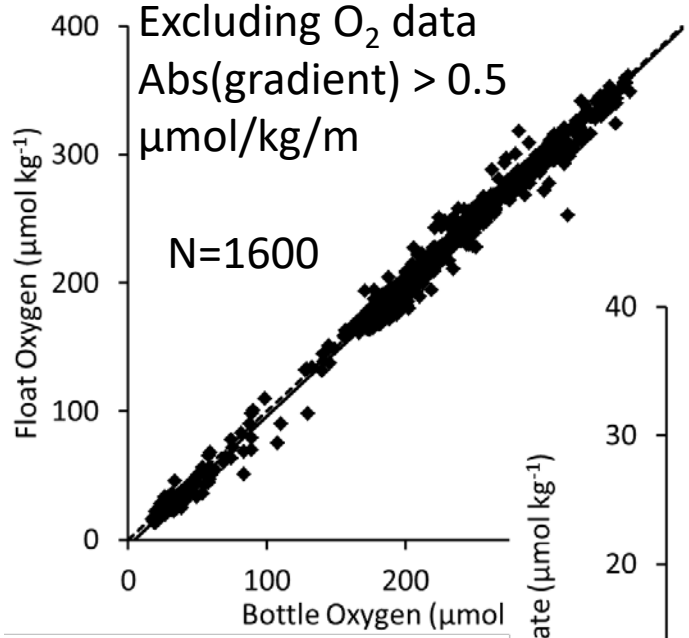
RESEARCH ARTICLE
10.1002/2017JC012838

Special Section:
The Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) Project:

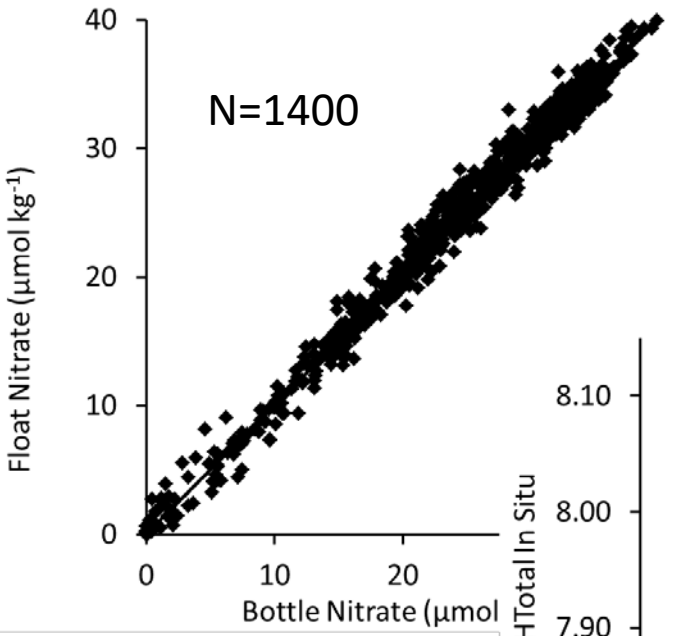
## Biogeochemical sensor performance in the SOCCOM profiling float array

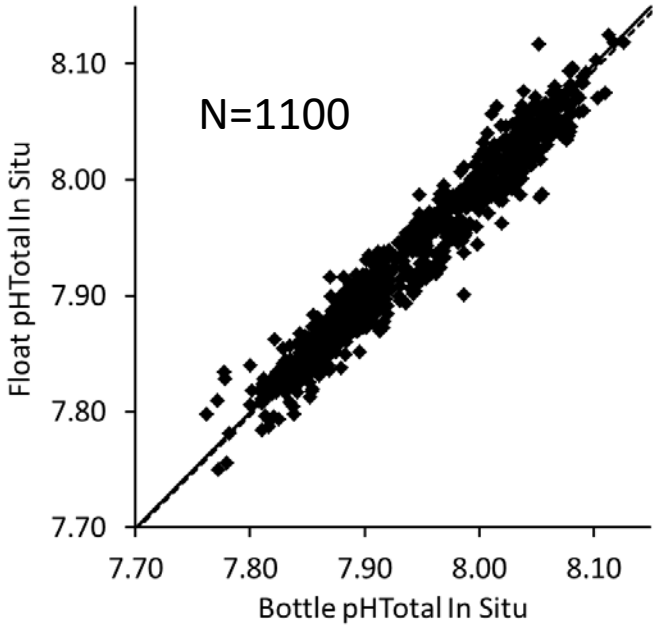
Kenneth S. Johnson[1], Joshua N. Plant[1], Luke J. Coletti[1], Hans W. Jannasch[1], Carole M. Sakamoto[1], Stephen C. Riser[2], Dana D. Swift[2], Nancy L. Williams[3], Emmanuel Boss[4], Nils Haëntjens[4], Lynne D. Talley[5], and Jorge L. Sarmiento[6]

biogeochemical Argo

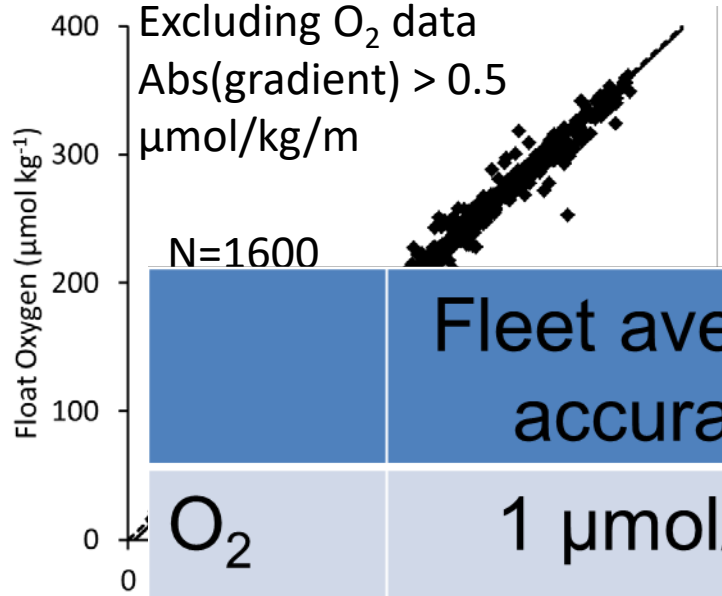



First float profile data after qc compared to bottle samples collected when float deployed (Johnson et al., JGR Oceans 2017).



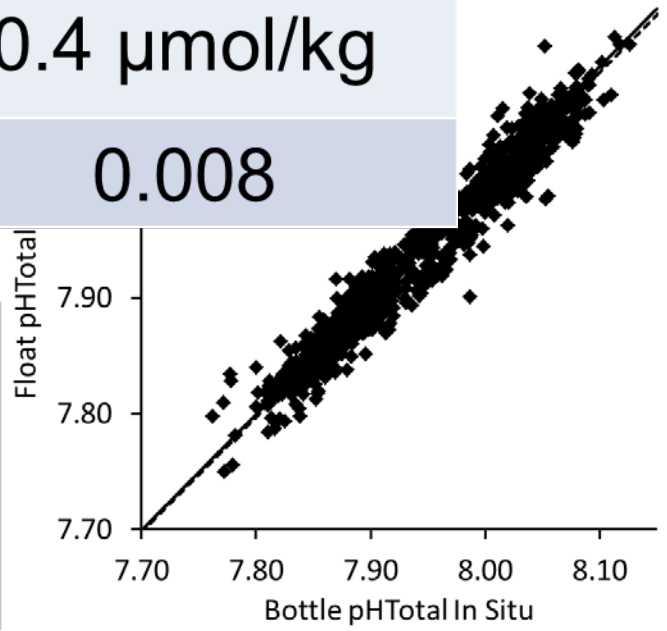




Bottle samples are not used to calibrate sensors, they are an independent assessment of accuracy.




First float profile data after qc compared to bottle samples collected when float deployed (Johnson et al., JGR Oceans 2017).

| | Fleet average accuracy | Fleet average precision (SD) |
|---|---|---|
| $O_2$ | 1 µmol/kg | 2 µmol/kg |
| $NO_3$ | 0.1 µmol/kg | 0.4 µmol/kg |
| pH | 0.005 | 0.008 |


Bottle samples are not used to calibrate sensors, they are an independent assessment of accuracy.

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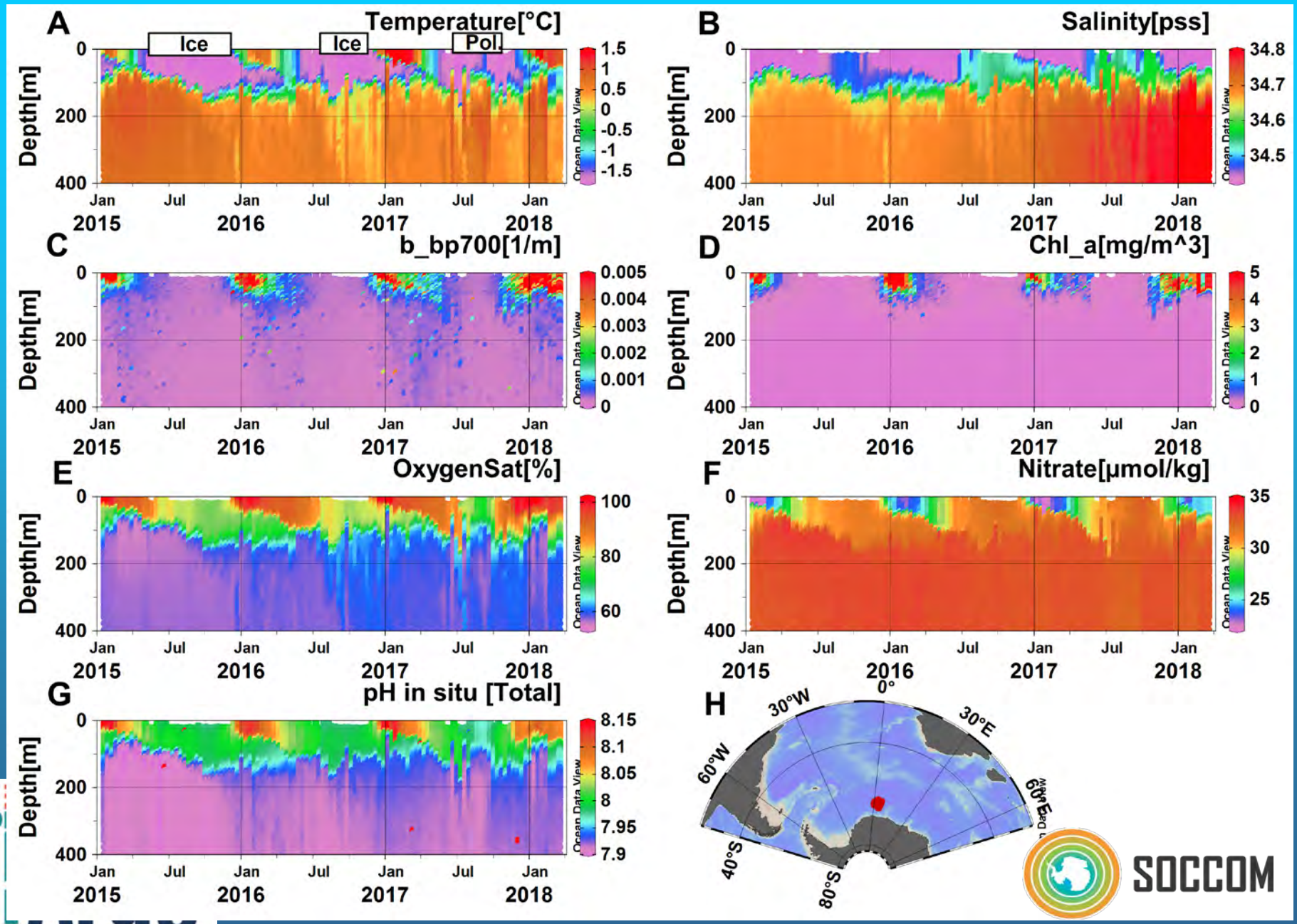
# BGC-Argo* has become the dominant source of open ocean biogeochemical data! 19 Nations deploying BGC floats.

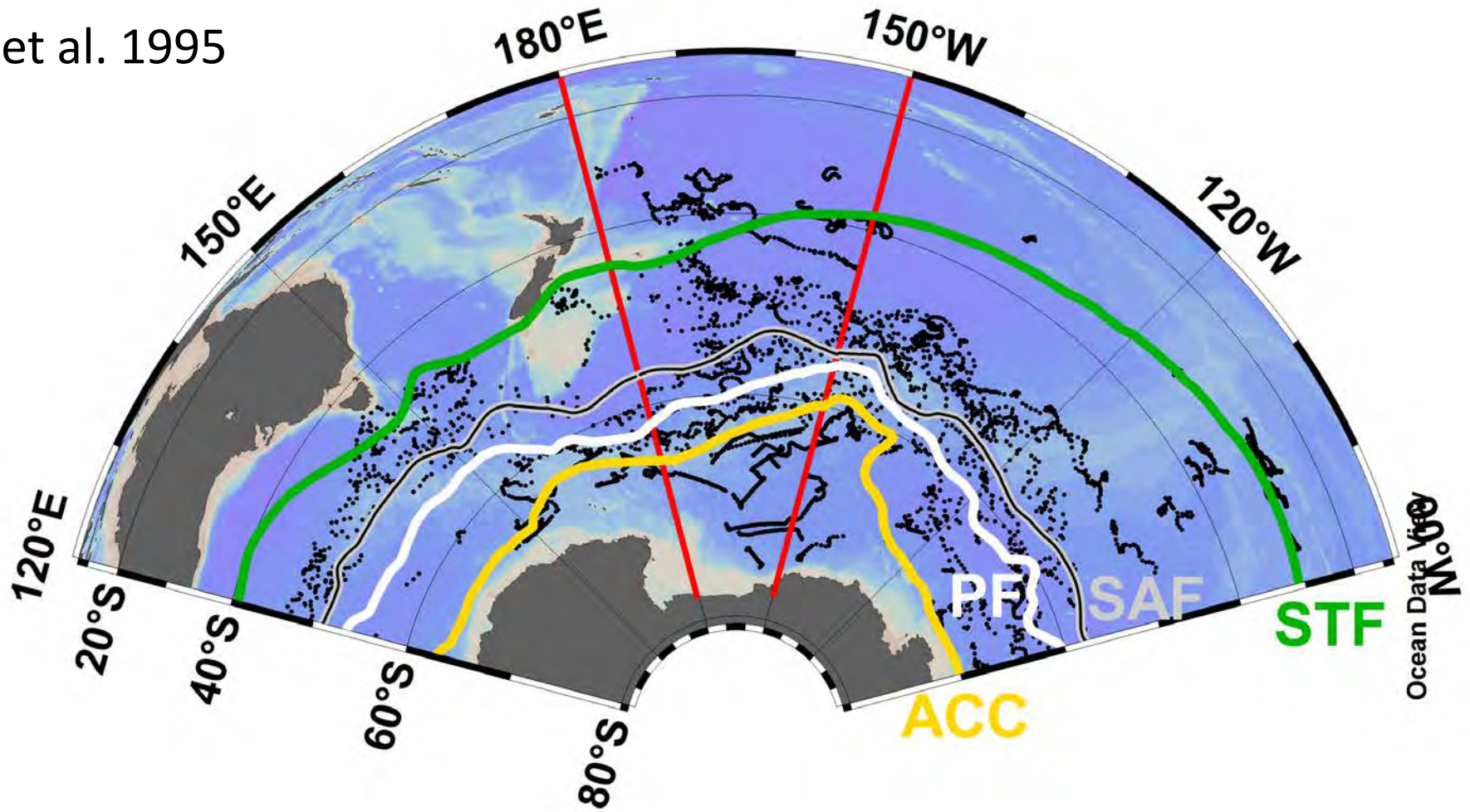
**Table 1. Profiles to depth > 900 m.**

| Parameter | Avg. Ship Profiles per year (2001-2010) | BGC-Argo Profiles per year | | BGC-Argo /Ship |
|---|---|---|---|---|
| | | 2016 | 2017 | |
| Oxygen | 1730 | 11332 | 12426 | 7 |
| Nitrate | 1231 | 3835 | 4265 | 3 |
| pH | 460 | 1862 | 2452 | 5 |
| Source | US National Oceanographic Data Center WOD | Argo Global Data Assembly Center | | |

# Float 9099/WMO 5904468



Front locations from Orsi et al. 1995




All data available in real-time at Argo GDAC or SOCCOMViz or FloatViz soccom.princeton.edu or www.mbari.org/floatviz

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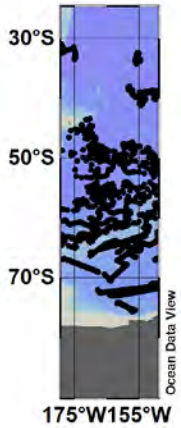
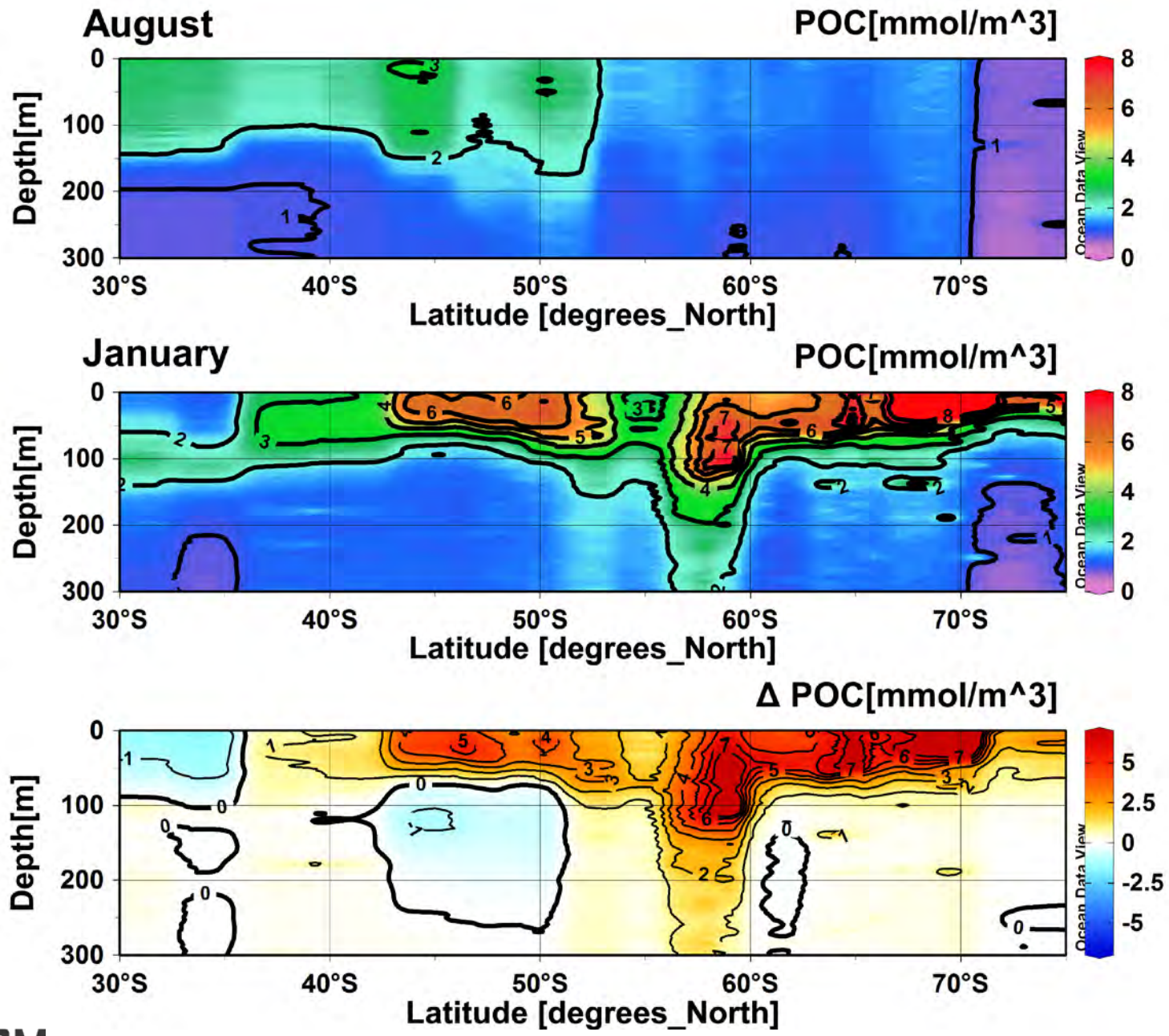
POC = backscatter * $3.12 \times 10^4$ /12

Johnson et al., JGR, 2017

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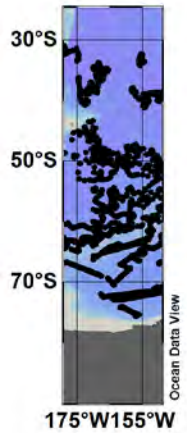
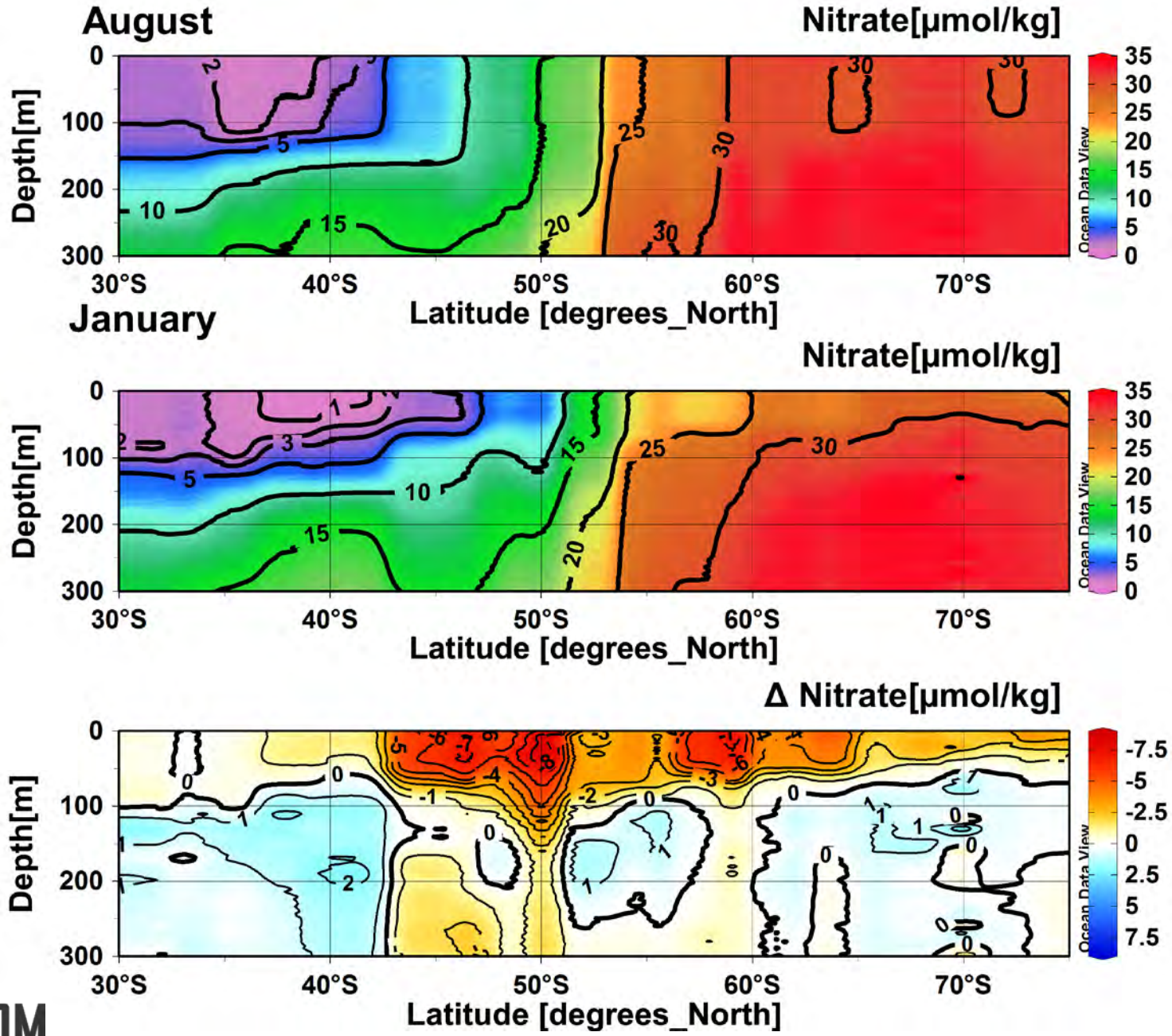

30°S
50°S
70°S
Ocean Data View
175°W155°W


August
Nitrate[µmol/kg]
Depth[m]
0
100
200
300
30°S
40°S
50°S
60°S
70°S
Latitude [degrees_North]
Ocean Data View
35
30
25
20
15
10
5
0
January
Nitrate[µmol/kg]
Depth[m]
Latitude [degrees_North]
Ocean Data View
Δ Nitrate[µmol/kg]
Depth[m]
Latitude [degrees_North]
Ocean Data View
-7.5
-5
-2.5
0
2.5
5
7.5

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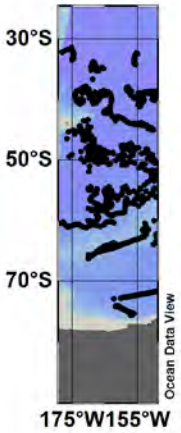
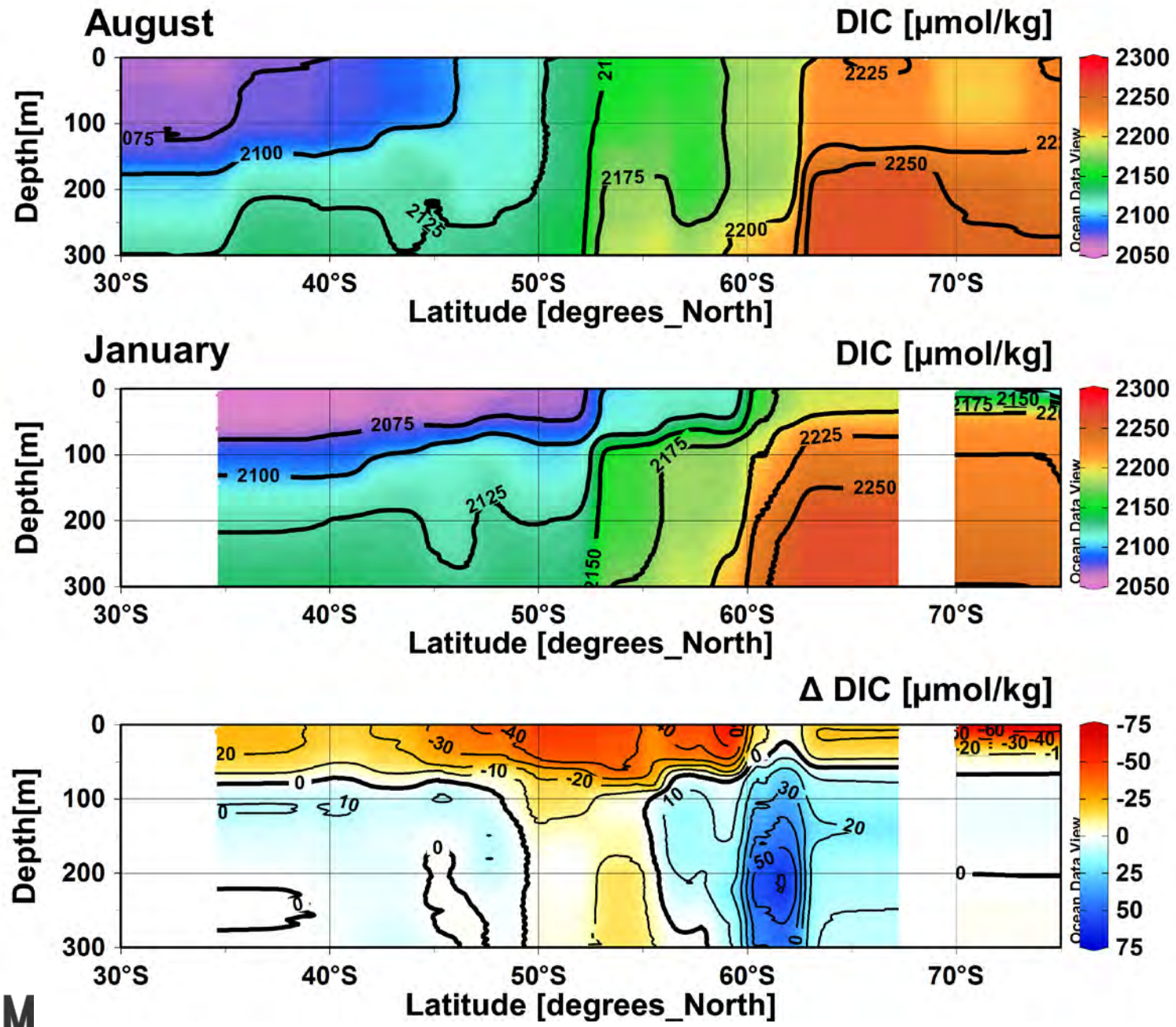
Dissolved Inorganic C determined from obs. pH & estimated $A_T$ (Carter et al., L&O:M, 2018)

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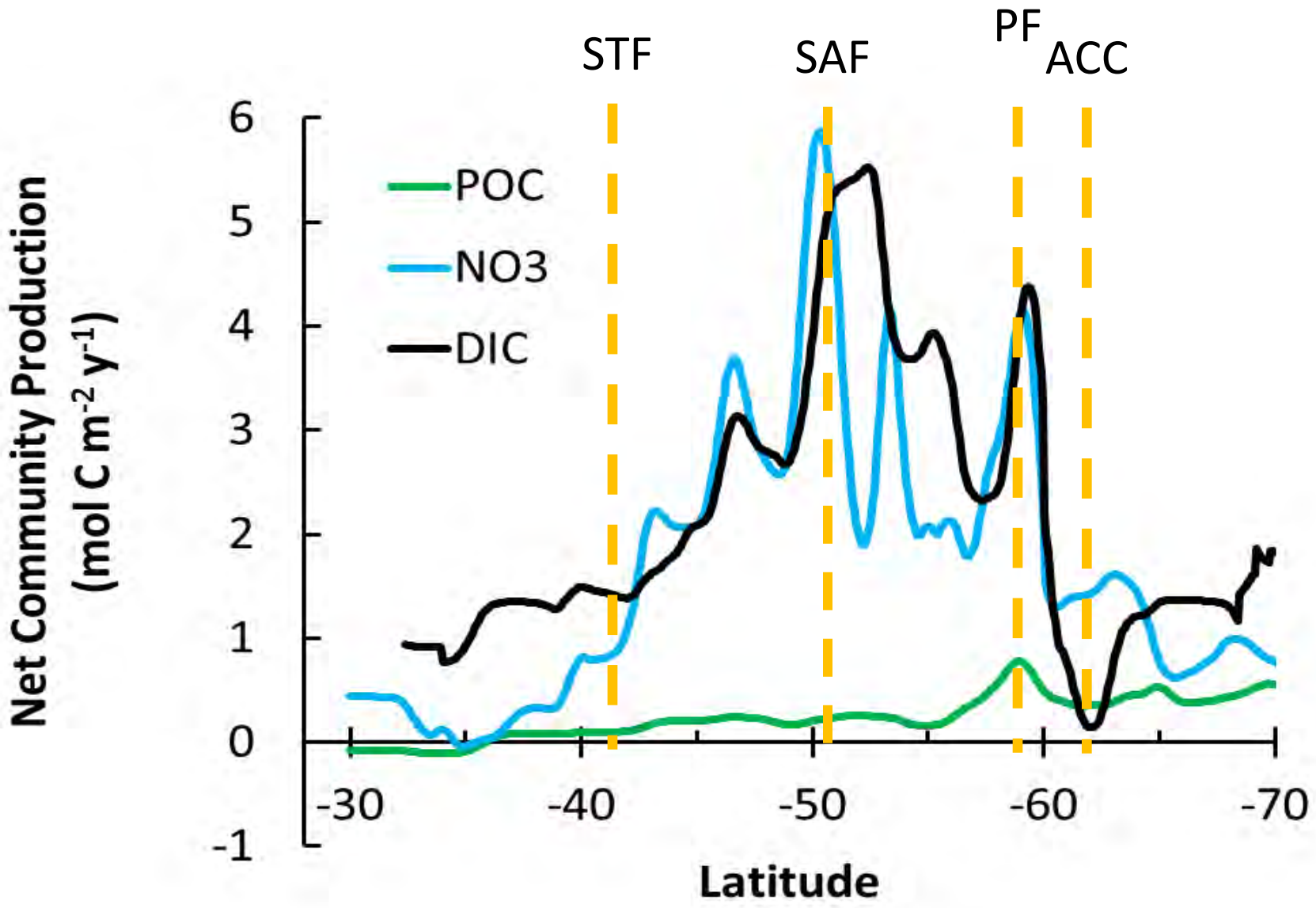
$NCP_{POC} << NCP_{NO3} *106/16 \cong NCP_{DIC}$



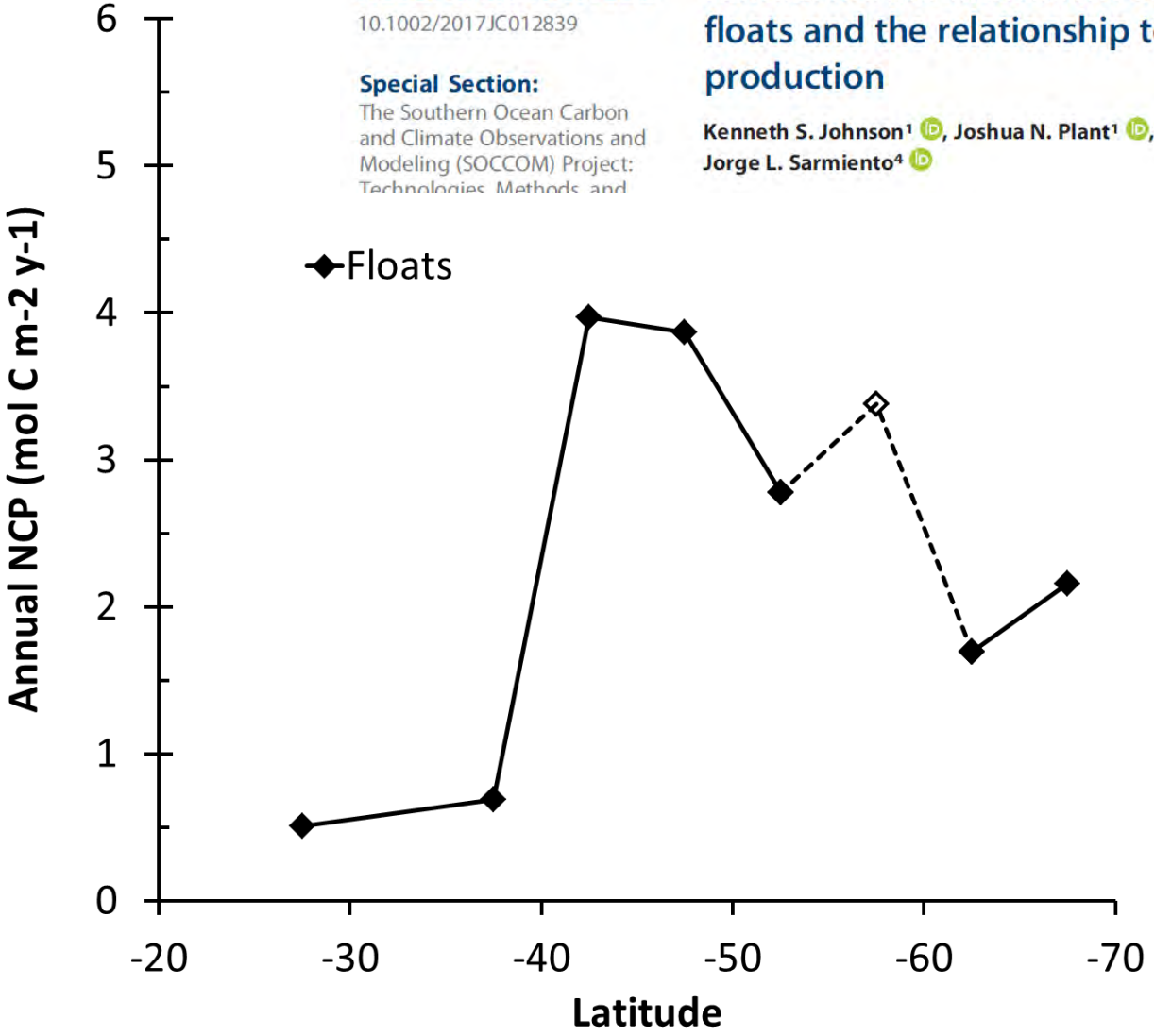
Journal of Geophysical Research: Oceans

RESEARCH ARTICLE
10.1002/2017JC012839

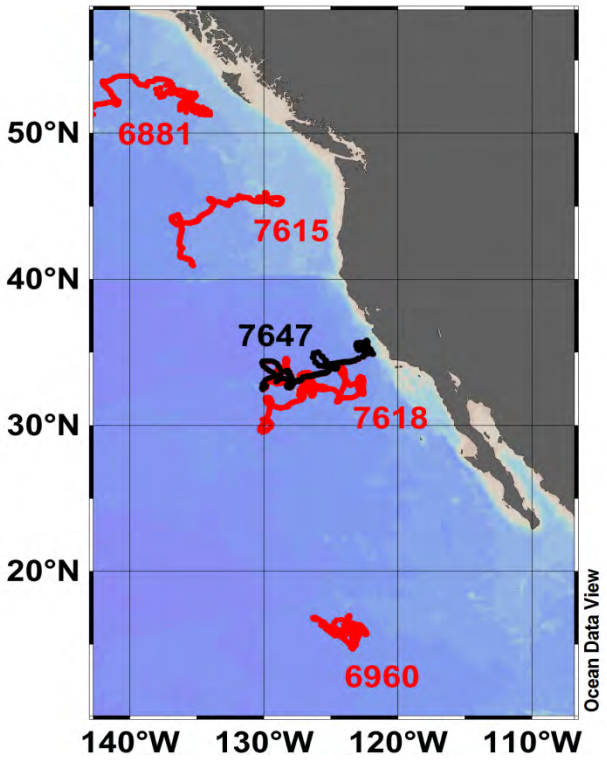
Special Section:
The Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) Project: Technologies, Methods, and

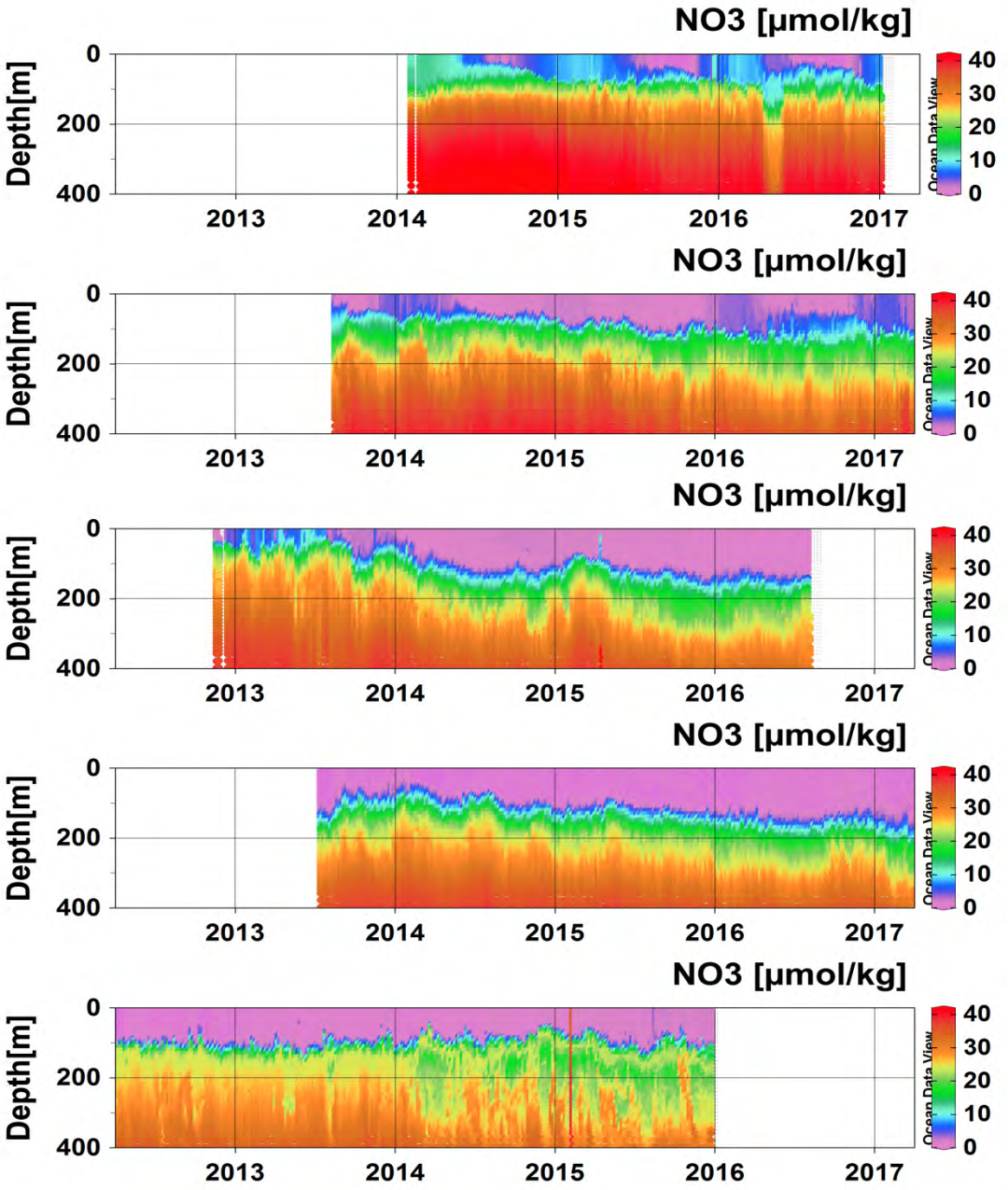
# Annual nitrate drawdown observed by SOCCOM profiling floats and the relationship to annual net community production

Kenneth S. Johnson[1], Joshua N. Plant[1], John P. Dunne[2], Lynne D. Talley[3], and Jorge L. Sarmiento[4]

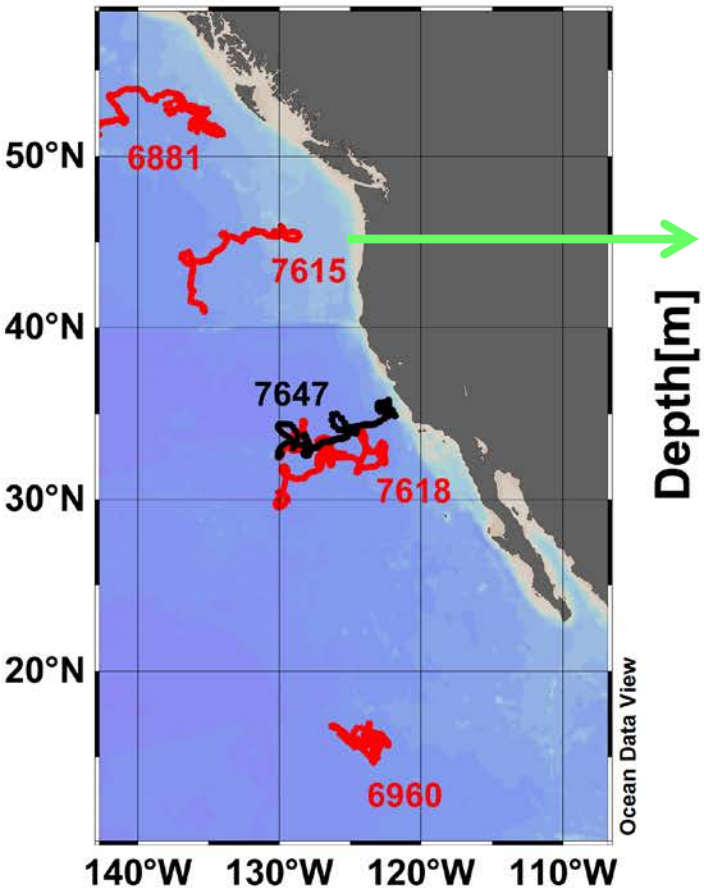


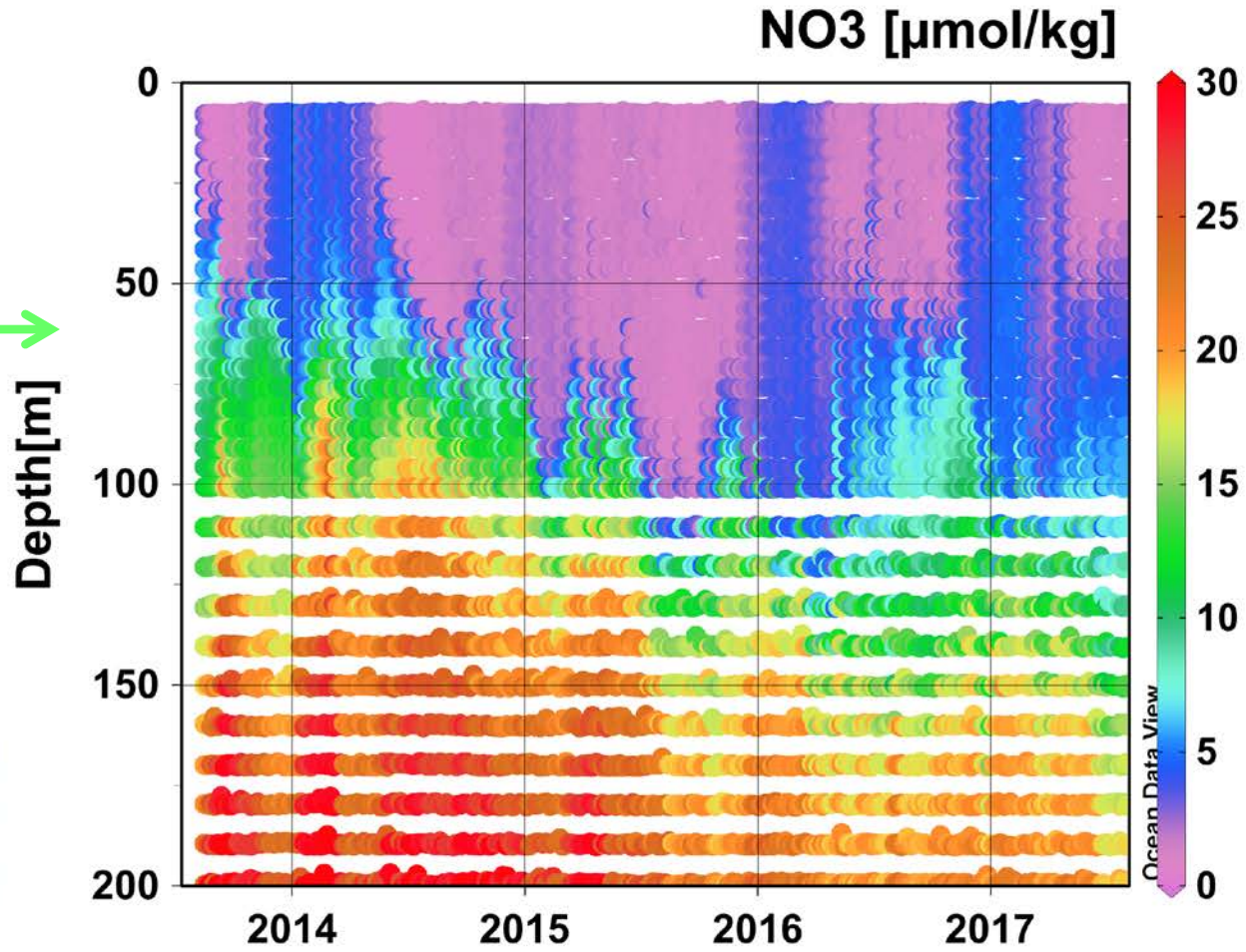

SOCCOM


6881
7615
7647
7618
6960
50°N
40°N
30°N
20°N
140°W
130°W
120°W
110°W
Ocean Data View


NO3 [µmol/kg]
Depth[m]
0
200
400
2013
2014
2015
2016
2017
Ocean Data View
40
30
20
10
0

SOCCOM


6881
7615
7647
7618
6960
50°N
40°N
30°N
20°N
140°W
130°W
120°W
110°W
Ocean Data View


NO3 [µmol/kg]
Depth[m]
0
50
100
150
200
2014
2015
2016
2017
30
25
20
15
10
5
0
Ocean Data View

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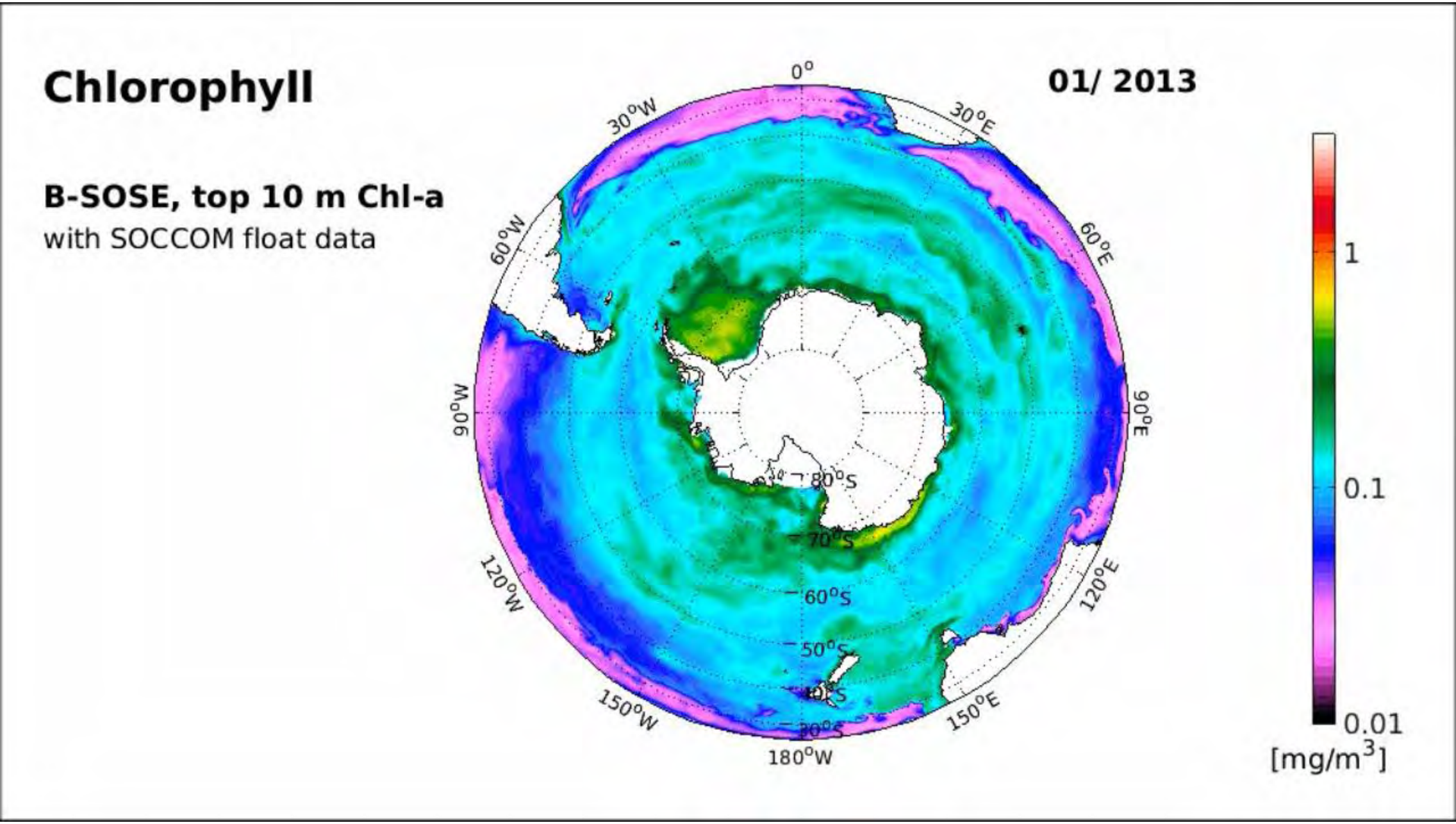
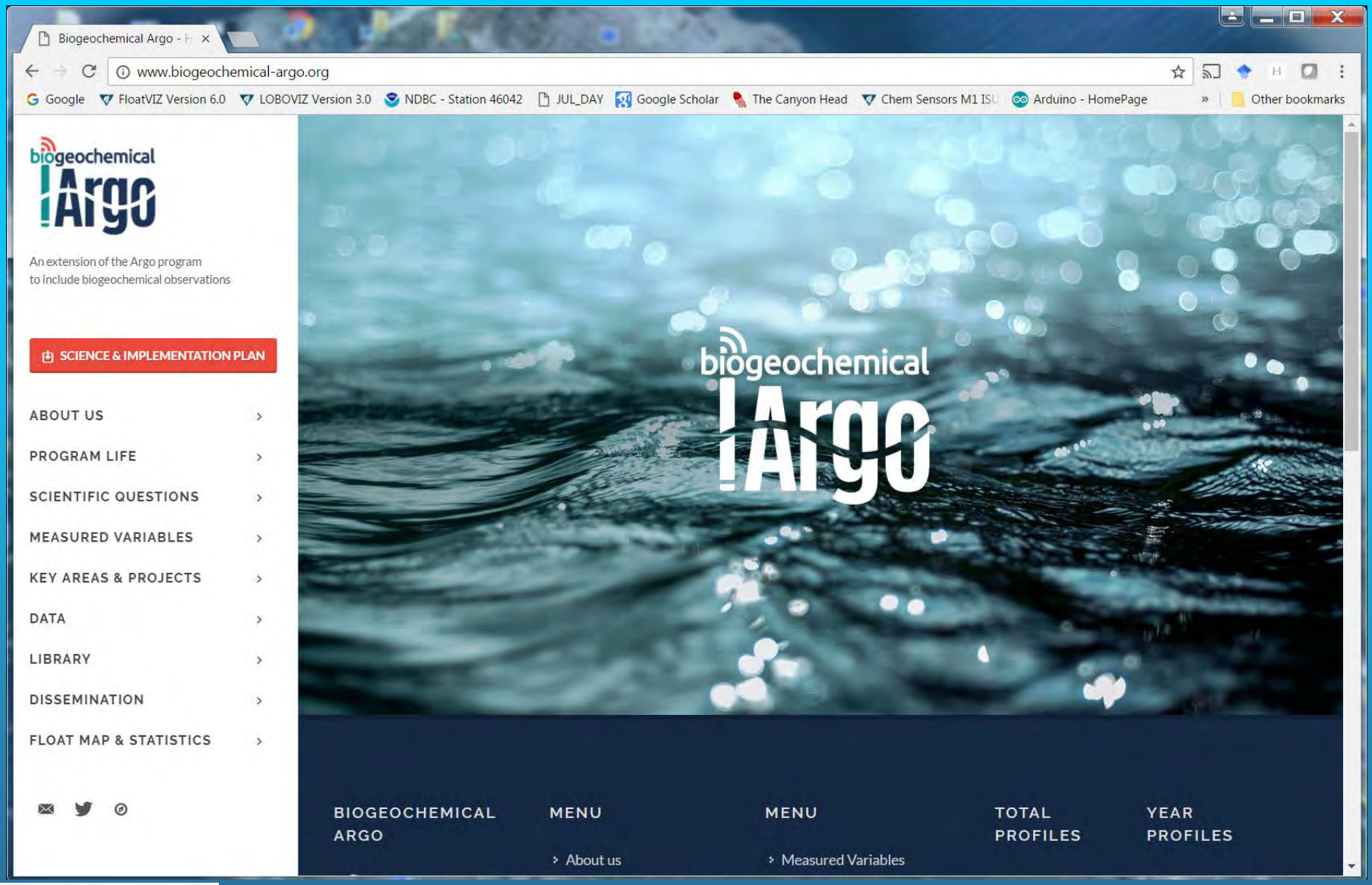
Data assimilating model – Biogeochemical-Southern Ocean State Estimate, 0.3 degree resolution, Matt Mazloff & Ariane Verdy, Scripps Institution of Oceanography

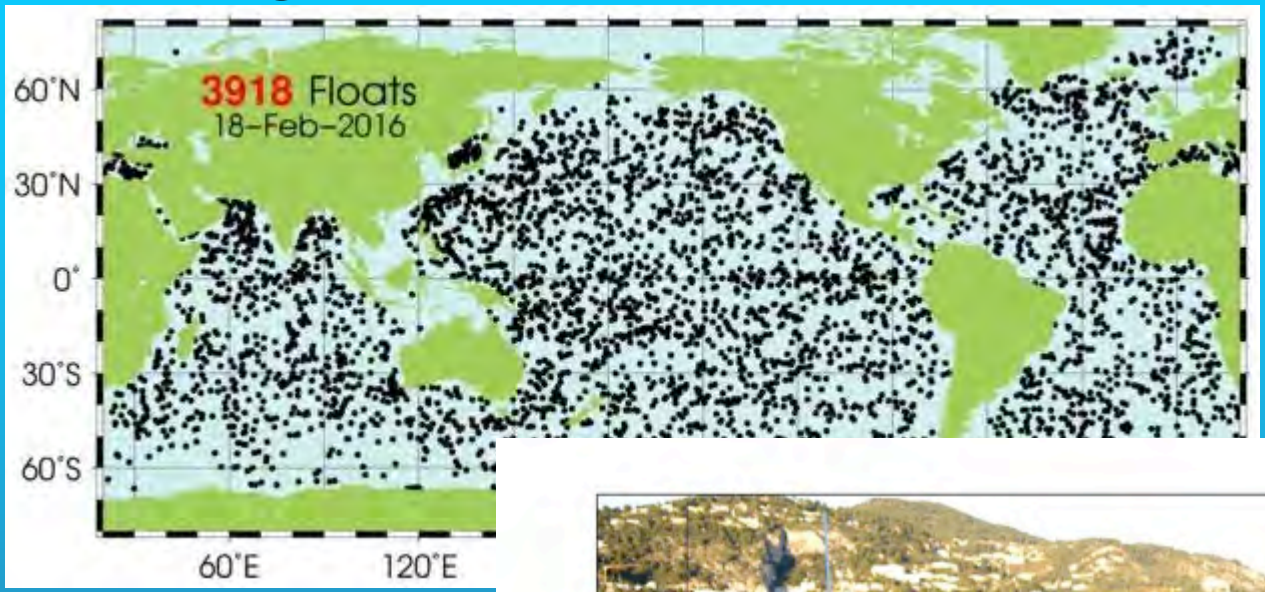





biogeochemical Argo

www.biogeochemical-argo.org

# Planning for a global network
# Meeting in Villefranche-sur-Mer, 11-13 January 2016.




**8 Nations represented**

Science plan and implementation discussion


Biogeochemical-Argo Network - Group photo

# The Rationale, Design, and Implementation Plan for Biogeochemical-Argo

*The extension of the Argo array of profiling floats to include biogeochemical sensors for pH, oxygen, nitrate, chlorophyll, suspended particles, and downwelling irradiance*

http://www.biogeochemical-argo.org

johnson@mbari.org, claustre@obs-vlfr.fr